

# **Validation of CERES-derived TERRA and AQUA **cloud** properties using DOE ARM surface observations**

**Xiquan Dong and Baike Xi, University of North Dakota**

- 1) What have we done from previously support ?**
- 2) What are we doing now (since last CERES STM) ?**
- 3) What do we plan to do in next 4 years ?**

# 1) What have we done from previously support ?

(Have attended all CERES STMs since 1996 and presented VIRS and MODIS cloud validation studies.

Following papers are either fully or partially supported by CERES

## At ARM SGP site

Dong, X., and G.G. Mace, 2003: Profiles of low-level stratus cloud microphysics deduced from ground-based measurements. *J. Atmos. and Oceanic Tech.*, 20, 42-53

Dong, X., P. Minnis, G.G. Mace, W.L. Smith Jr, M. Poellot, R. Marchand, and A. Rapp, 2002: Comparison of stratus cloud properties deduced from surface, GOES, and aircraft data during the March 2000 ARM Cloud IOP. *J. Atmos. Sci.*, 59, 3265-3284.

Dong, X., P. Minnis, T.P. Ackerman, E.E. Clothiaux, G.G. Mace, C.N. Long, and J.C. Liljegren, 2000: A 25-month database of stratus cloud properties generated from ground-based measurements at the ARM SGP site. *J. Geophys. Res.* 105, 4529-4538.

Dong, X. P. Minnis, and B. Xi, 2004: A climatology of midlatitude continental clouds from ARM SGP site. Part I: Low-level Cloud Macrophysical, microphysical and radiative properties. Submitted to *J. Climate*. \_

# 1) What have we done from previously support (cont.)?

## At ARM NSA Site

Dong, X., G.G. Mace, P. Minnis, and D.F. Young, 2001: Arctic stratus cloud properties and their effect on the surface radiation budget: Selected cases from FIRE ACE. *J. Geophys. Res.* 106, 15 297-15 312.

Dong, X., and G.G. Mace, 2003: Arctic stratus cloud properties and radiative forcing derived from ground-based data collected at Barrow, Alaska. *J. of Climate*, 16, 445-461.

## Aerosol-cloud interactions

Penner, J.E., X. Dong, and Y. Chen, 2003: Observational evidence for a change in radiative forcing due to the indirect aerosol effect. *Nature*. Jan. 15, 2004.

## **2) What are we doing now ?**

**Validation of TRMM VIRS cloud Property retrievals using ground-based measurements at the DOE ARM SGP site.**

**Dong, X. and B. Xi, University of North Dakota**

**P. Minnis, B. Wielicki, G.G. Mace, B. Xi, S.Sun-Mack and Y. Chen**

**G.G. Mace, University of Utah**

**Validation of TERRA MODIS cloud Property retrievals using ground-based measurements at the DOE ARM SGP site.**

**In preparation for JGR**

## 2) What are we doing now (cont.) ?

### TRMM VIRS

#### **Time period**

From Jan. 1998 to June 2001 at the ARM SGP site.

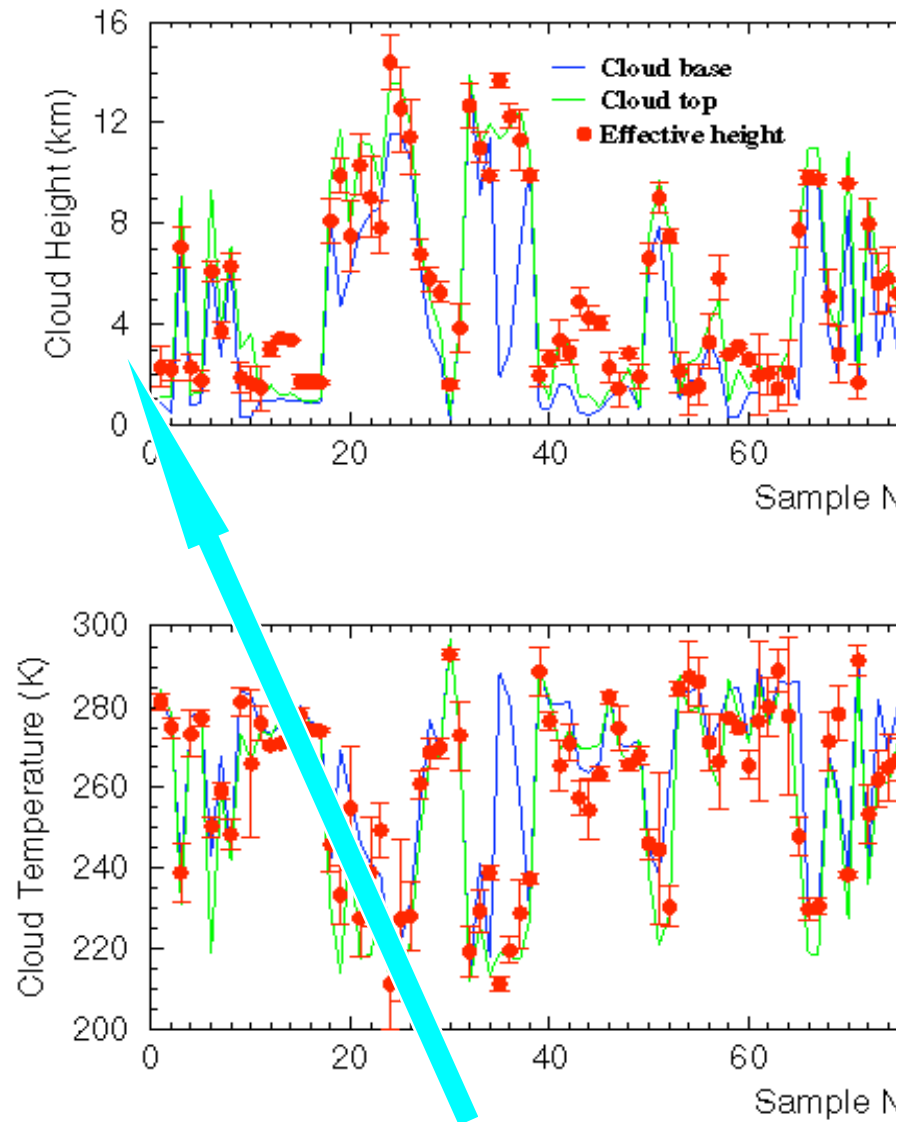
#### **Surface:**

DOE ARM SGP measurements and retrievals averaged over a 1-hour interval centered at the time of the satellite overpass.

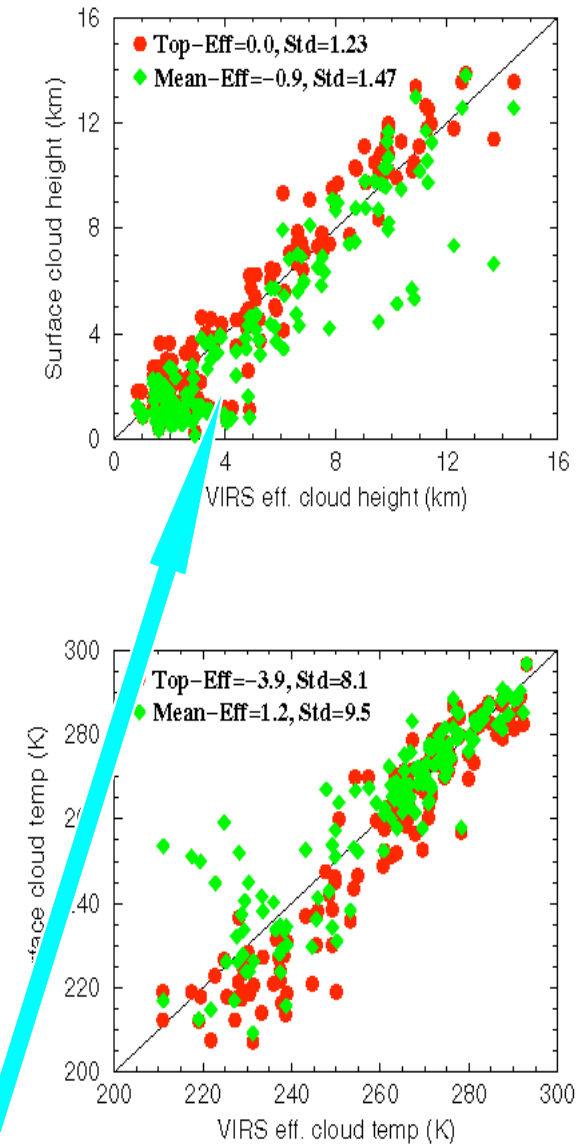
#### **Satellite:**

Average all pixels within a 30-km x 30-km area centered on the ARM SGP site

Daytime optically thick cloud height and t

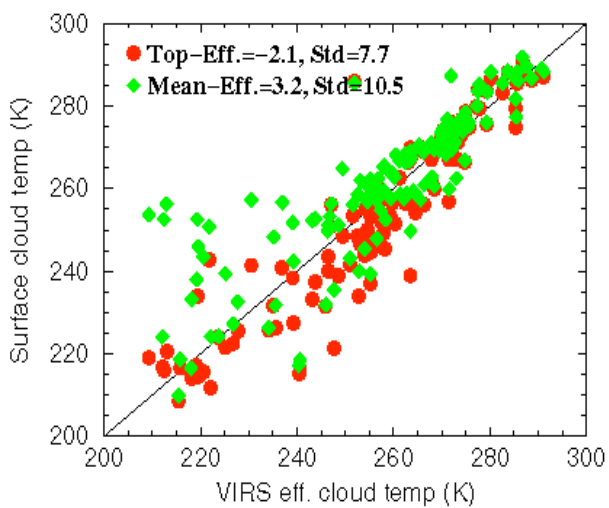
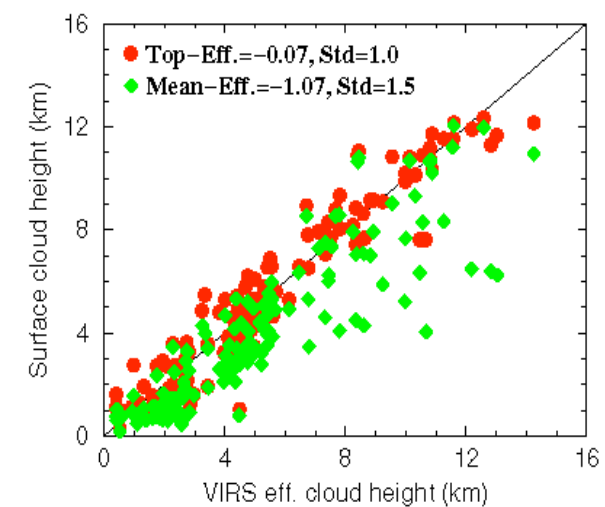


Daytime optically thick clouds the ARM SGP site ( $\tau > 5$ )

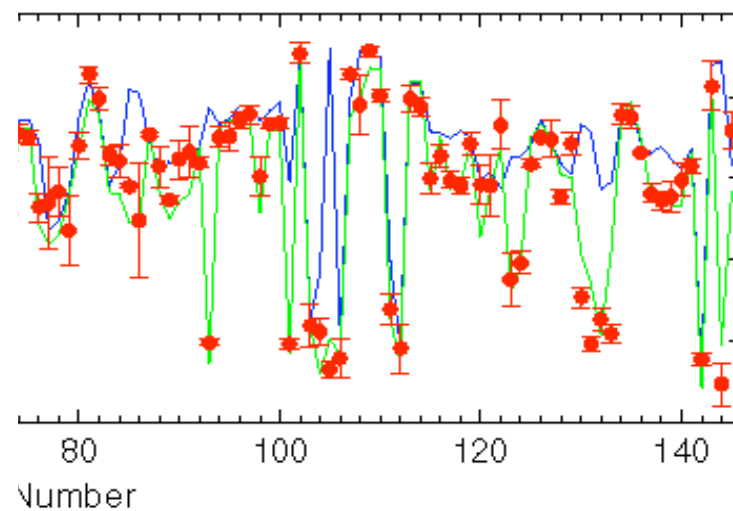
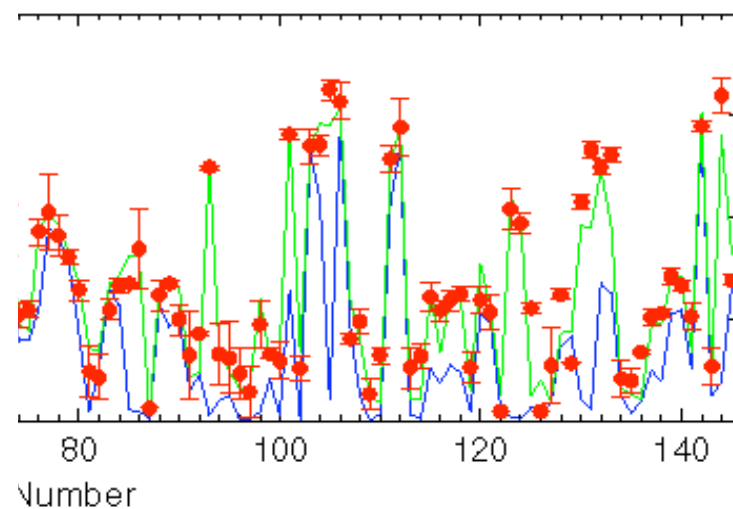


Some of low cloud heights are overestimated

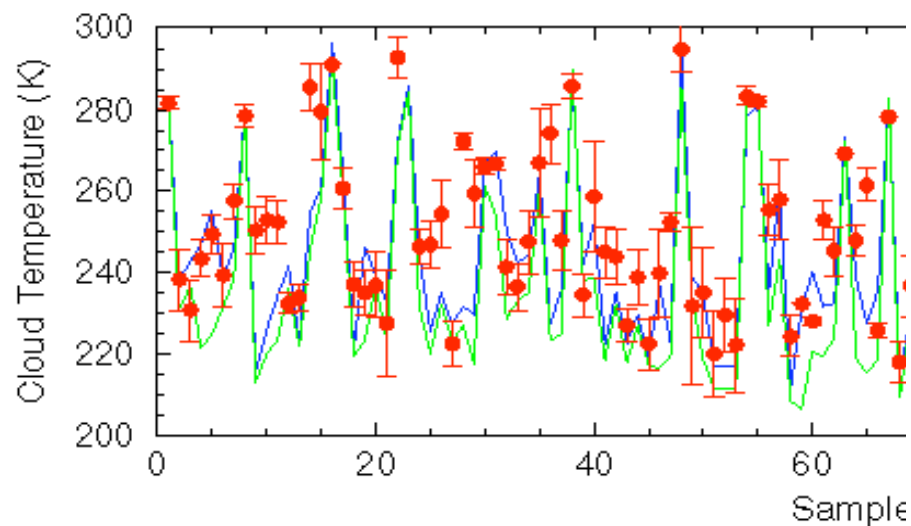
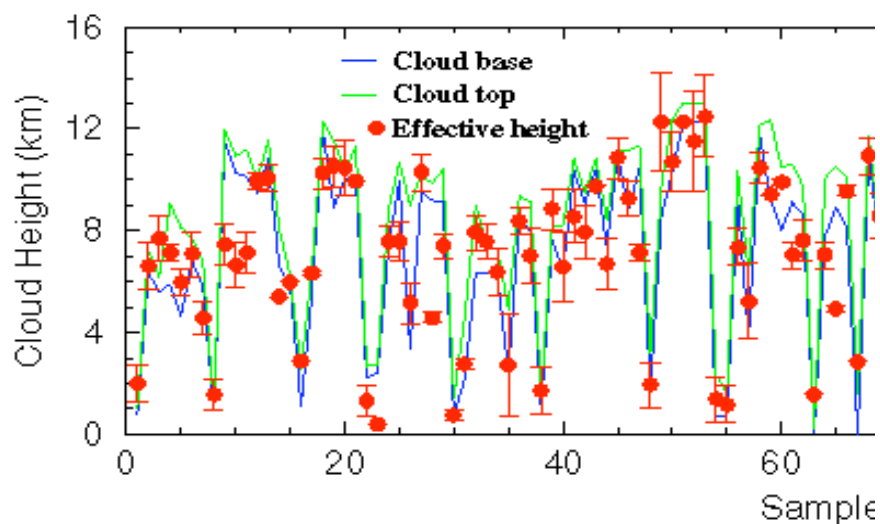
Nighttime optically thick clouds the ARM SGP site ( $\tau > 5$ )



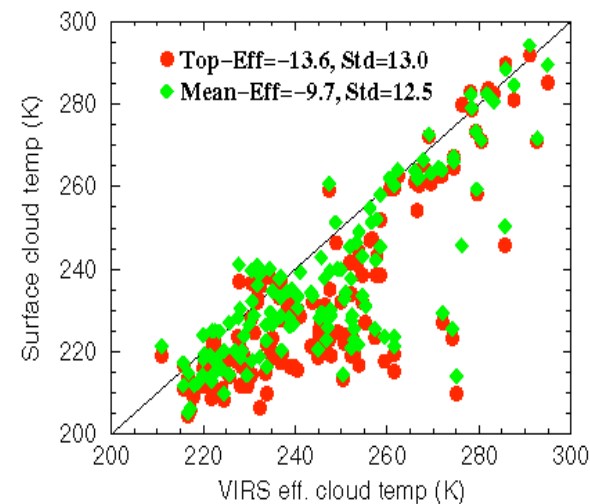
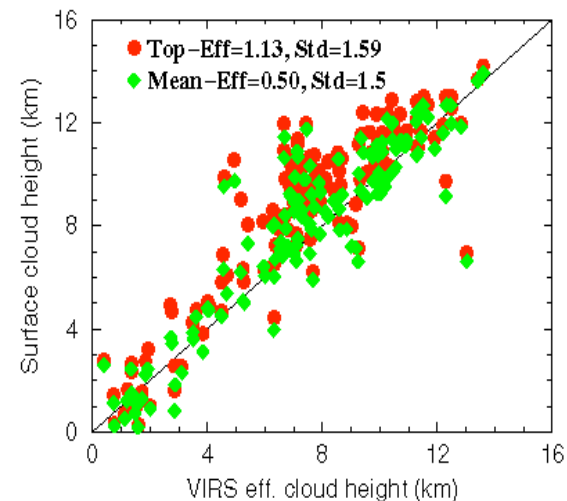
temperature at the ARM SGP Site ( $\tau > 5$ )



## Daytime optically thin cloud height and

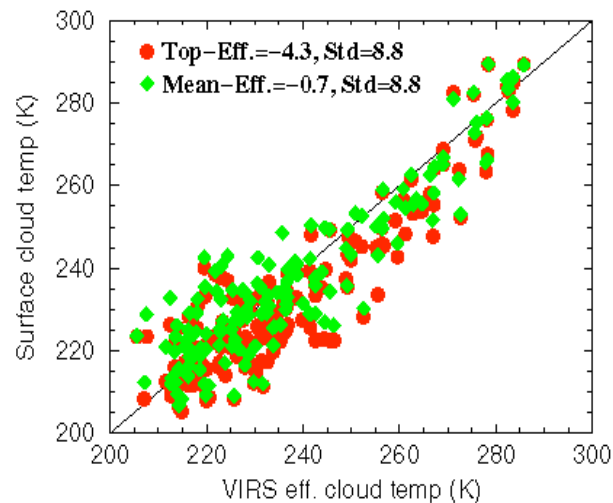
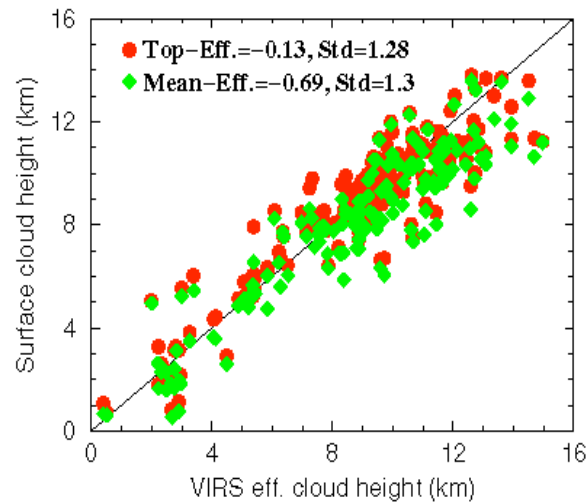


## Daytime optically thin clouds the ARM SGP site ( $\tau < 5$ )

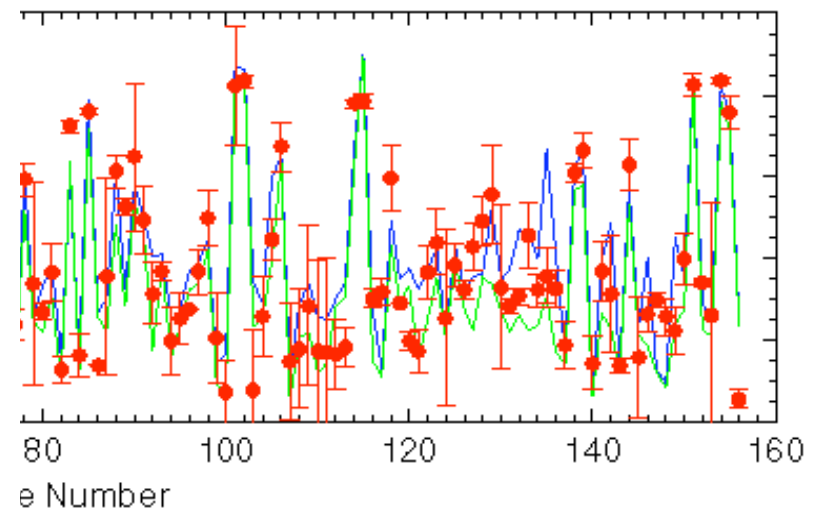
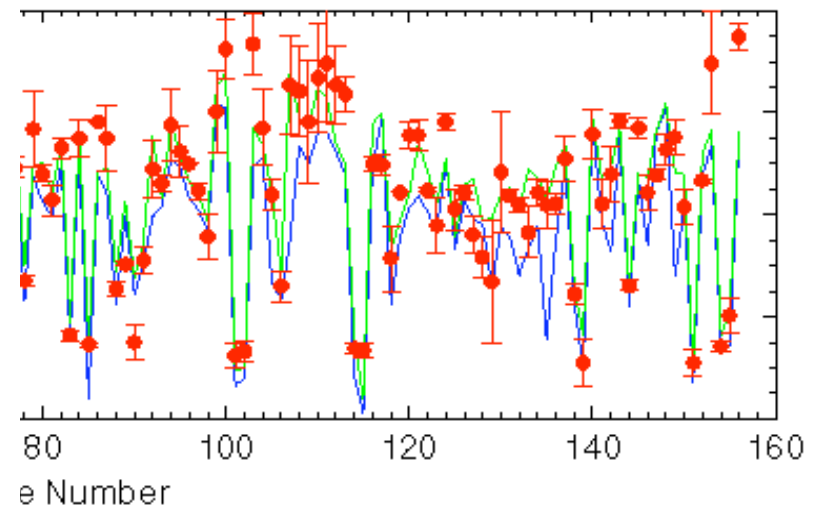




Nighttime optically thin clouds the ARM SGP site ( $\tau < 5$ )

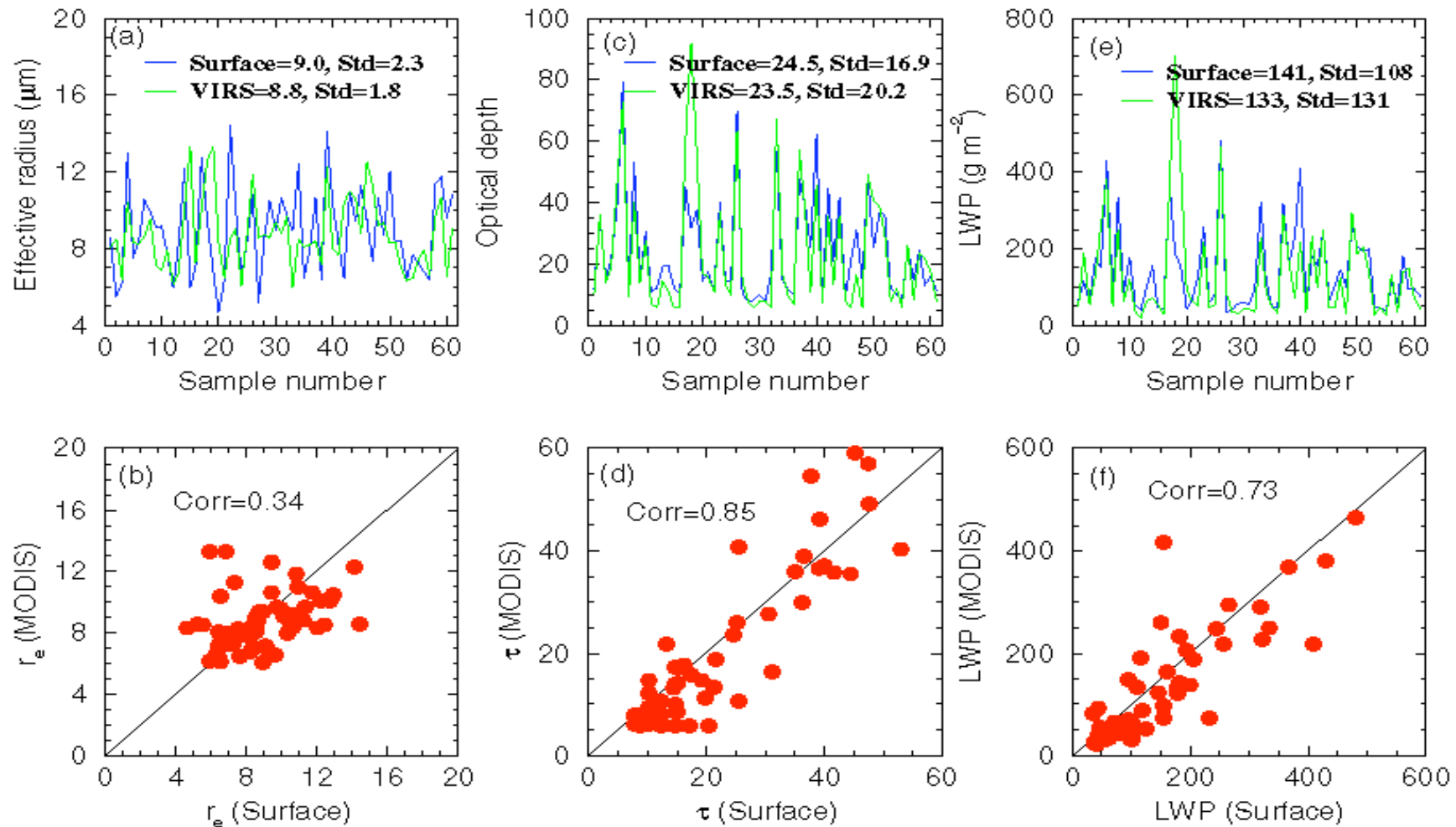


1 temperature at the ARM SGP Site ( $\tau < 5$ )



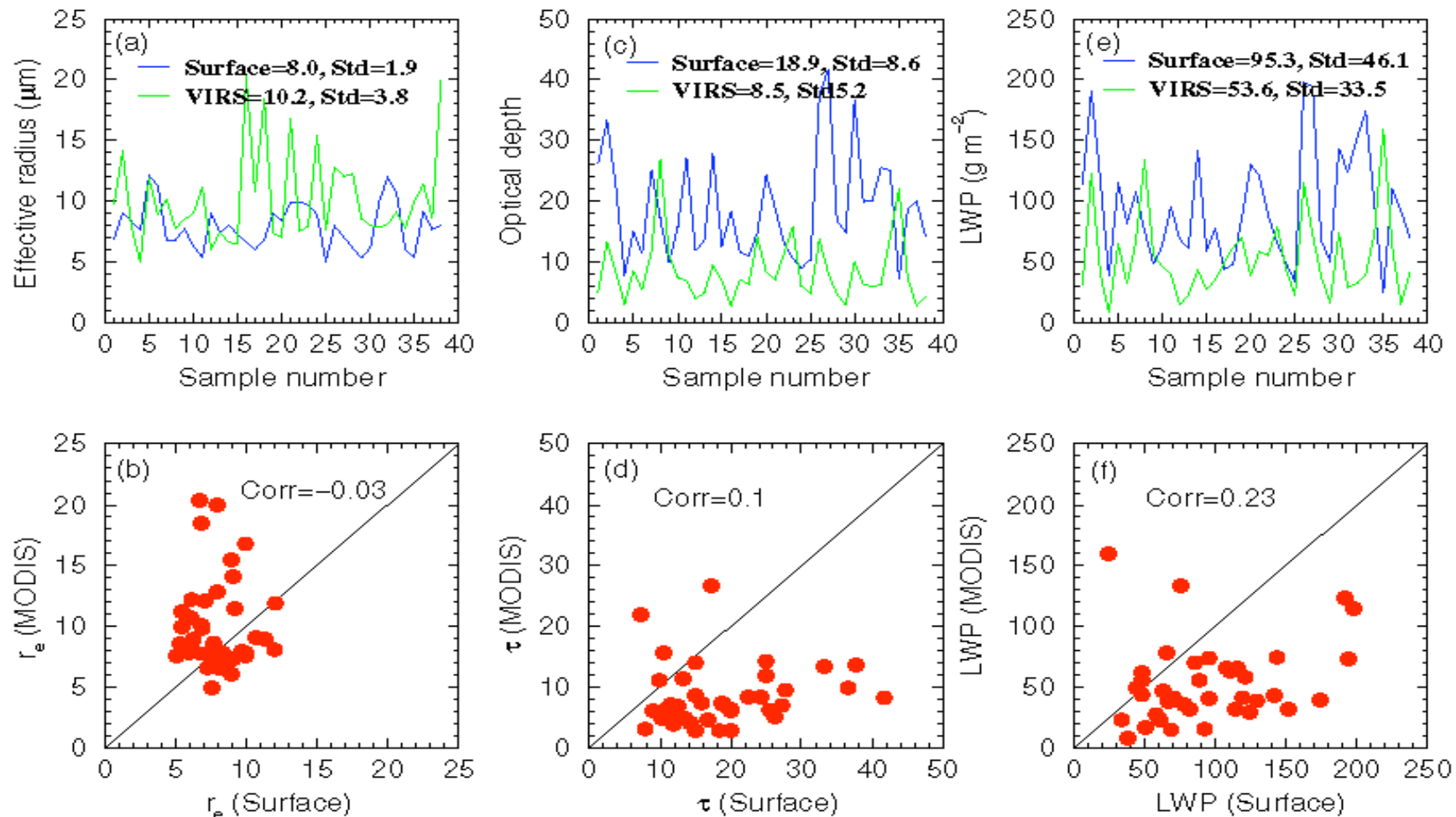
**A further study is warranted for VIRS nighttime optically thin cloud height and temp retrievals.**

**Daytime stratus clouds at the ARM SGP Site (January 1998 to June 2001)**



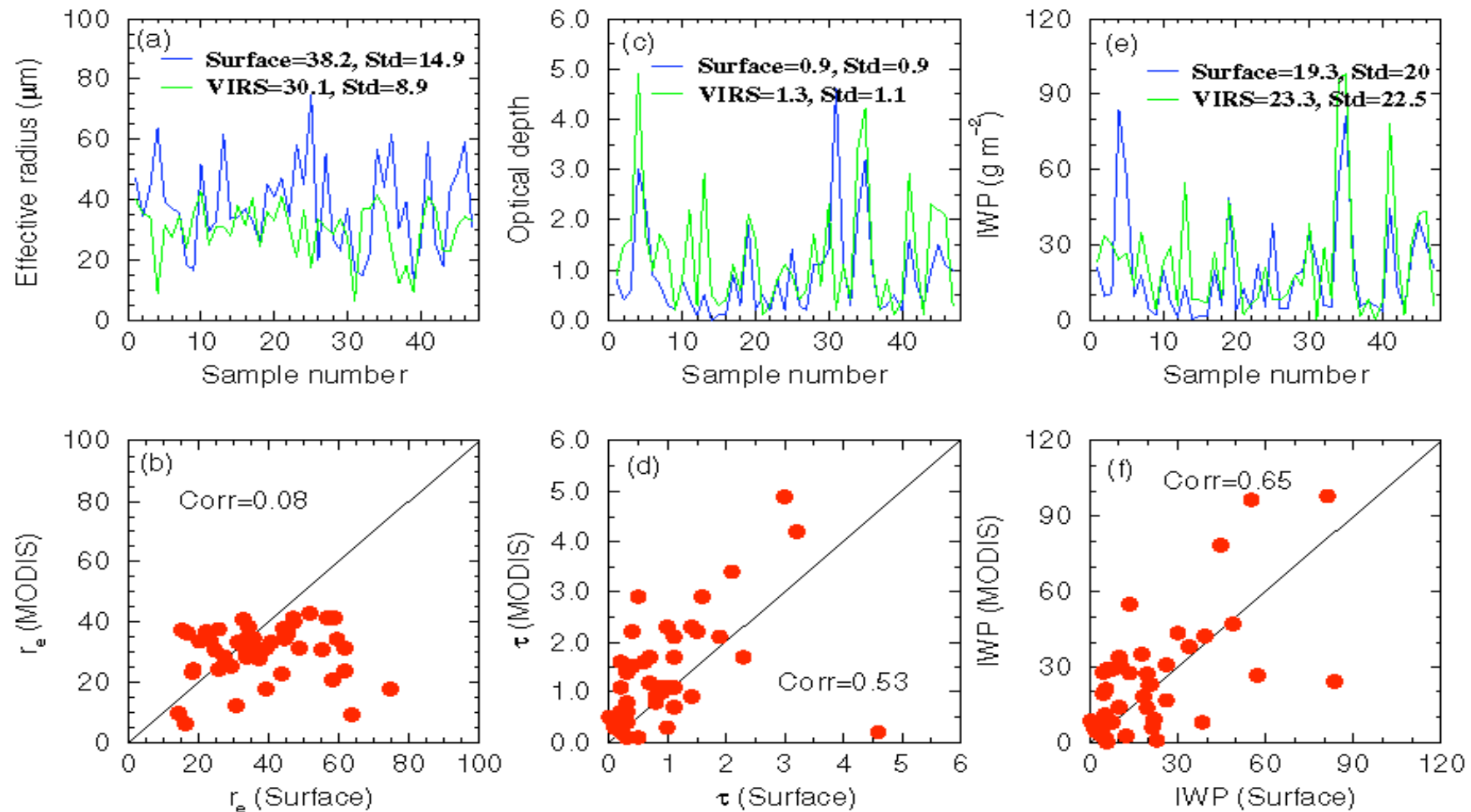
**Both VIRS and surface retrievals are close to Dong et al. (2004, J. Climate) results from 6 years of ARM SGP data.**

### Nighttime stratus clouds at the ARM SGP Site (January 1998 to June 2001)



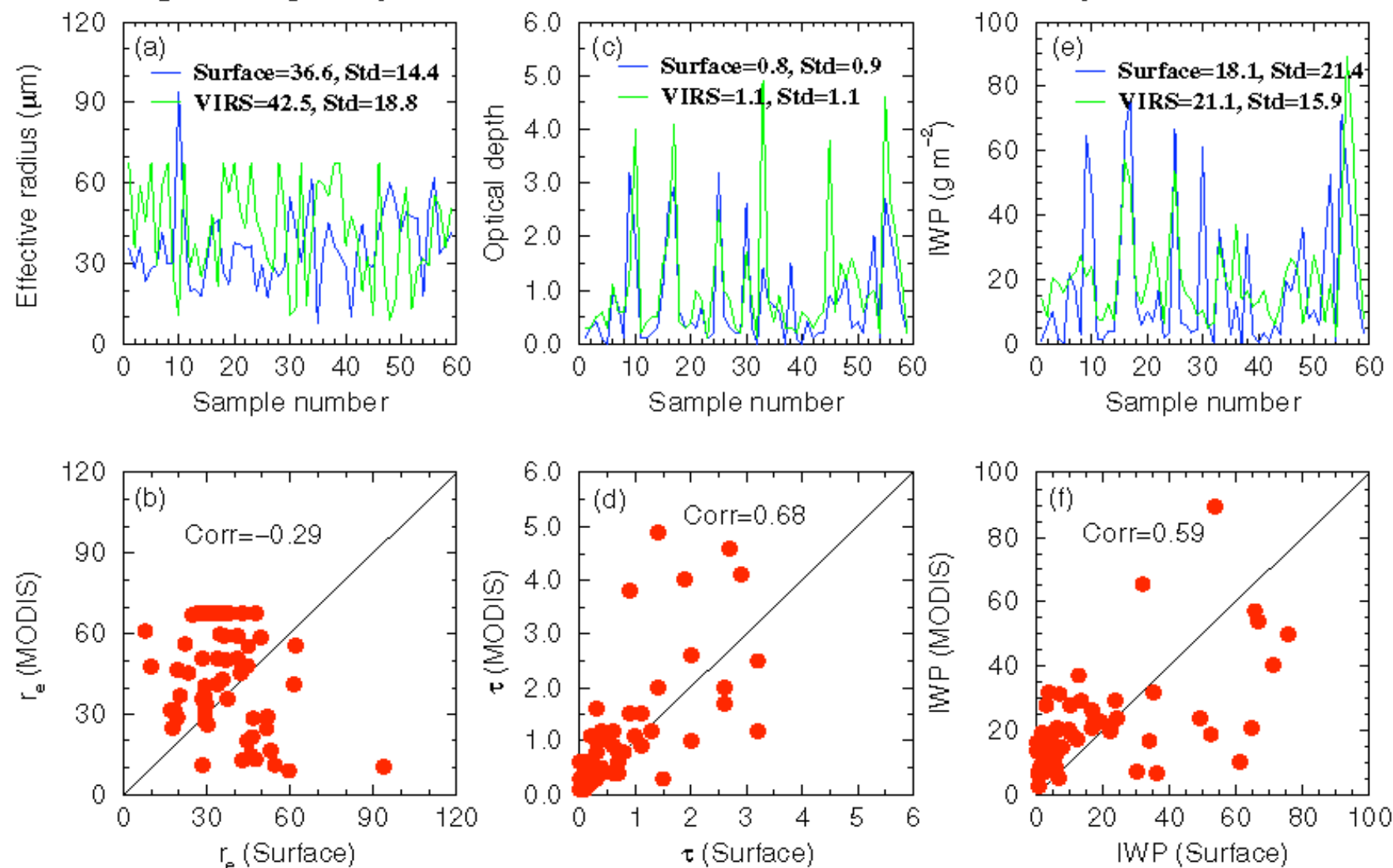
**Nighttime VIRS retrieved optical depth are about half of surface retrievals, so resulting in its LWP. A further study is needed.**

# Daytime cirrus clouds at the ARM SGP Site (January 1998 to June 2001)



**The VIRS retrievals agree well with surface results. The VIRS comparison is better than MODIS comparison.**

# Nighttime optically thin cirrus clouds at the ARM SGP Site (January 1998 to June 2001)



# **Summary of VIRS comparisons**

- 1) Both day and night optically thick height and temp agree well with surface observations except some of low clouds**
- 2) There is an excellent agreement in daytime optically thin cloud height and temp, but nighttime results are needed to do further study.**
- 3) VIRS daytime stratus cloud retrievals are very close to the surface results, and climatology of stratus clouds at SGP.  
The night VIRS cloud optical depth and LWP are underestimated.**
- 4) Both day and night VIRS optically thin cirrus cloud results agree to surface retrievals. The VIRS cirrus comparisons are better than the MODIS comparisons.**

### **3) What do we plan to do in next 4 years ?**

- \ Complete validation of CERES cloud retrievals with independent ground-truth observations should account for the following variables: (1) cloud types (low, middle, high, multiple layer, and broken), (2) surface types (ocean, vegetated land, non-vegetated land, mountains, snow-covered land, and ice-covered water), (3) seasons, (4) day and night, and (5) viewing and illumination angles (e.g., satellite view zenith angle  $VZA$  and solar zenith angle  $SZA$ ).**
- \ A complete quantitative assessment requires at least 100 independent samples for each of the conditions, and the independent samples must be typically 100-300 km apart and separated by 6 to 12 hours in time for clouds and radiation.**

**Table 2. Timeline for tasks outlined in this proposal**

<b>Tasks</b>	<b>cloudy cases</b>	<b>FY04</b>	<b>FY05</b>	<b>FY06</b>	<b>FY07</b>
1. Compare single-layer Terra-MODIS cloud properties at SGP from years 2000 to 2006 (day)	Height and temp ~ 100/yr Stratus ~20/yr Optically thin cirrus ~ 20/yr	X-----	-----	-----	-----X
2. Compare single-layer Terra-MODIS cloud properties at SGP from years 2000 to 2006 (night)	Height and temp ~ 100/yr Stratus ~20/yr Optically thin cirrus ~ 20/yr	X-----	-----	-----	-----X
3. Compare single-layer Aqua-MODIS cloud properties at SGP from years 2002 to 2006 (day)	Height and temp ~ 100/yr Stratus ~20/yr Optically thin cirrus ~ 20/yr	X-----	-----	-----	-----X
4. Compare single-layer Aqua-MODIS cloud properties at SGP from years 2002 to 2006 (night)	Height and temp ~ 100/yr Stratus ~20/yr Optically thin cirrus ~ 20/yr	X-----	-----	-----	-----X
5. Compare multi-layer and broken cloud properties at SGP from years 2000-2006 for Terra, and 2002-2006 for Aqua (day, night)	Multi-layer ~20/yr Broken ~20/yr			X-----	-----X
6. Angular dependence of MODIS cloud properties at SGP	>100 cases for SZA and VZA				X----- X
7. Compare MODIS $r_s$ retrievals with surface radar-retrieved vertical profiles at SGP	Single-layer stratus ~ 20 Single-layer cirrus ~ 20		X-----X		
8. Optically thick clouds at SGP	Single-layer cirrus ~ 20			X-----	-----X



# This SUMMER Aircraft/surface/satellite IOP at UND

## Goals:

Short-term: To validate NASA satellite cloud retrievals and UND ground-based measurements using aircraft data

Long-term: To extend NASA validations from ARM sites to UND

**Aircraft:** UND Citation research aircraft, 10 hours for low clouds, funded by ND NASA EPSCoR program

**Surface:** UND ground-based cloud and radiation observing system

Laser ceilometer and 5 cm radar \ cloud base and top heights

915 MHz wind profiler \ cloud base and top heights, and updraft velocity (donate from NOAA)

Microwave radiometer \ cloud LWP (borrow from Jay Mace)

PSPs and PIRs \ downward/upward SW and LW fluxes

Weather station \ Surface T, P, RH, WS, WD.

**Satellite:** MODIS and GOES results will be provided by Pat Minnis.

You are welcome to join us, and contributing more flight hours is **EXTREMELY** welcome. Contact [dong@aero.und.edu](mailto:dong@aero.und.edu)

**Thanks for your attention!**

**Have a nice day!**

**What is a nice day ?**

**Everyday you are above ground**

